

REMARKS

The following remarks are provided in response to the Office Action mailed February 14, 2006 and the Interview Summary mailed April 24, 2006 in which the Examiner:

- rejected claims 21-24 under 35 U.S.C. §103(a) as being unpatentable over United States Patent No. 5,972,123 to Verhaverbeke (hereinafter Verhaverbeke) or United States Patent No. 6,015,505 to David et al. (hereinafter David) as evidenced by United States Patent No. 6,902,969 to Adetutu et al. (herein after Adetutu), US 2004/0191974 to Gilmer et al. (hereinafter Gilmer), and United States Patent No. 5,466,389 to Ilardi et al. (hereinafter Ilardi).
- rejected claims 6-15 and 25-30 under 35 U.S.C. §103(a) as being unpatentable over Verhaverbeke or David in view of Adetutu, Gilmer, and Ilardi.
- allowed claims 16-20.
- pointed out that the limitations of “the chelating agent has a diameter that exceeds the thickness of the metal layer, in absence of any active ingredient that has diameter smaller than the thickness of the metal layer” are not in the claims (interview summary).

The applicants respectfully request reconsideration of the above referenced patent application for the following reasons:

Claims 6-15 and 21-30 rejection under 35 U.S.C. §103(a)

The Examiner rejected claims 21-24 as being unpatentable over Verhaverbeke or

David as evidenced by Adetutu, Gilmer, and Ilardi and rejected claims 6-15 and 25-30 as being unpatentable over Verhaverbeke or David in view of Adetutu, Gilmer, and Ilardi.

The applicants herein amend base claims 6, 11, 21 and 25 and respectfully request reconsideration of base claims 6, 11, 21 and 25 in view of the amendments and the following arguments. Claim sets 7-10, 12-15, 22-24 and 26-30 are dependent on base claims 6, 11, 21 and 25, respectively, and the applicants request that they be reconsidered as presented.

The applicants teach a method for making a semiconductor device wherein a wet etchant contains at least one active etching ingredient (e.g. a chelating agent), wherein the diameter of all present active etching ingredients is selected to exceed the thickness of a metal layer that is being etched. Portions of the metal layer that are underneath a masking layer (e.g. a polysilicon layer) are not etched because the diameters of all the active etching ingredients are larger than the dimension between the masking layer and the bottom of the metal layer. Thus, the size of the active etching ingredients prevents their access to masked portions of the metal layer. This process may result in a vertical (anisotropic) etch of the metal layer instead of an undercut (isotropic) etch, which would be typically anticipated for a wet etchant.

Verhaverbeke discloses a method of using reactive chemical process liquids for etching or cleaning the surfaces of semiconductor wafers to remove any unwanted layer or part thereof from the silicon surface, such as an oxide layer, a nitride layer, an aluminum layer or a titanium layer, or for use in controlled oxide etching (col. 5, lines 42-47). The reactive chemical process liquids (i.e. active etching ingredients) suitable for

practicing the invention disclosed include aqueous solutions of hydrochloric acid, ammonium hydroxide, hydrogen peroxide, sulfuric acid, sulfuric acid and ozone, hydrofluoric acid, chromic acid, phosphoric acid, acetic acid, nitric acid, and ammonium fluoride buffered hydrofluoric acid (col. 5, lines 11-24). It is well known in the art that the active etching ingredients in these wet etchants have dimensions considerably smaller than the thickness of metal layers being etched for semiconductor device fabrication and furthermore undercut such layers underneath masking layers. Therefore, Verhaverbeke does not disclose a wet etchant that contains at least one active etching ingredient wherein the diameters of all active etching ingredients exceed the thickness of a metal layer that is being etched.

David discloses a method to achieve a “desired isotropic process **16**” (col. 6, line 66; Fig. 3A) by applying a solution that may be used to wet etch TiW in the presence of plated C4 (PbSn) solder bumps. The solution contains hydrogen peroxide, potassium sulfate, and potassium EDTA; wherein, the hydrogen peroxide level primarily influences the overall etch rate, while the potassium sulfate level controls the extent of passivation of the PbSn surface during etching. Thus, the hydrogen peroxide, which has a diameter considerably smaller than the thickness of the metal film being etched, is the active etching ingredient which “primarily influences the overall etch rate” (col. 7, lines 15-17). The potassium EDTA is a chelating agent, which binds to already etched metals to prevent their re-deposition on the solder-bump surface and to prevent the catalytic decomposition of the etch bath itself (col. 7, lines 12-22). Thus, David discloses a wet etchant wherein not all of the active etching ingredients have a diameter that exceeds the

thickness of the metal layer being etched.

Adetutu discloses a method wherein the etching of a metal layer **116** is achieved with a wet etch process. The wet etch may be a piranha clean, which is comprised of sulfuric acid and hydrogen peroxide in solution with water, although other wet etches may also be effective (col. 2, lines 62-66). The thickness of layer **116** is “preferably 50 Angstroms but could be as low as 30 Angstroms or could be higher than 50 Angstroms” (col. 3, lines 32-34). It is well known in the art that the diameters of the active etching ingredients disclosed in Adetutu are much smaller than the thickness of the metal film **116** being etched. Therefore, Adetutu does not disclose a wet etchant that contains at least one active etching ingredient wherein the diameters of all active etching ingredients exceed the thickness of a metal layer that is being etched.

Gilmer discloses a method wherein the removal of a gate conductor (i.e. metal layer) is “preferably” accomplished with a dry, gaseous plasma etch (p. 3 [0024]). The gate conductor material disclosed “may have a thickness of 50 to 500 Angstroms” (p. 3 [0023, 0025]). It is well known in the art that the diameters of the active etching ingredients in such dry etches are significantly smaller than the thicknesses of the metal films being etched. Furthermore, it is well known in the art that a vertical (anisotropic) etch may be achieved by modifying the bias (applied voltage) applied to the plasma, but the diameters of the active etching ingredients remain much smaller than thickness of the metal layer being etched. Therefore, Gilmer does not disclose a wet etchant that contains at least one active etching ingredient wherein the diameters of all active etching ingredients exceed the thickness of a metal layer that is being etched, nor does Gilmer

disclose a method of achieving a vertical (anisotropic) etch by using all active ingredients larger than the dimensions of the etched film.

As the Examiner points out, Ilardi discloses that EDTA is a typical chelating agent (col. 4, lines 8-11). However, Ilardi does not disclose a wet etchant that contains at least one active etching ingredient wherein the diameters of all active etching ingredients exceed the thickness of a metal layer that is being etched.

Therefore, none of Verhaverbeke, David, Adetutu, Gilmer, nor Ilardi either alone or in combination, disclose a method selecting the diameter of all active etching ingredients in a wet etchant to exceed the thickness of a metal layer being etched. Furthermore, none of Verhaverbeke, David, Adetutu nor Gilmer, either alone or in combination, disclose a method of wet etching a metal layer wherein the metal layer is not undercut, thereby attaining an anisotropic profile, as a consequence of utilizing a wet etchant with at least one active etching ingredient wherein the diameters of all present active etching ingredients exceed the thickness of the metal layer.

Claims 16-20 allowed

The applicants respectfully acknowledge that the Examiner allowed claims 16-20.

Interview Summary

The applicants would like to thank the Examiner for taking the time to meet in a phone interview on April 18, 2006. During the interview, the Examiner pointed out that the limitations of “the chelating agent has a diameter that exceeds the thickness of the

metal layer, in absence of any active ingredient that has diameter smaller than the thickness of the metal layer” are not in the claims. The applicants have accordingly amended the claims to include those limitations, as discussed above in detail.

CONCLUSION

The applicants submit that they have overcome the Examiner's claim rejections and that they have the right to claim the invention as set forth in the listed claims. The Examiner is respectfully requested to contact the undersigned by telephone if it is believed that such contact would further the examination of the present application.

Pursuant to 37 C.F.R. 1.136(a)(3), applicant(s) hereby request and authorize the U.S. Patent and Trademark Office to (1) treat any concurrent or future reply that requires a petition for extension of time as incorporating a petition for extension of time for the appropriate length of time and (2) charge all required fees, including extension of time fees and fees under 37 C.F.R. 1.16 and 1.17, to Deposit Account No. 02-2666.

Respectfully submitted,

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5/10/06
Dated

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